# OPTICAL WAVELENGTH SPLITTER

Inventors:
Edward Belotserkovsky
Steve Axelrod
Igor Germanenko
Jenson Luis

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## BACKGROUND OF THE INVENTION

**[0001]** The present invention relates to optical spectroscopic detectors and especially to multichannel spectroscopic measurement units.

**[0002]** The optical energy detection at a particular optical wavelength is used for a number of different purposes. Often, detected light intensity at different wavelengths is used to produce a ratio that gives information about a process, such a paper making processes. Typically, one of the wavelengths is related to a process variation such as water level and another is a reference wavelength related to process conditions.

**[0003]** Figure 1A shows a typical prior art system. In this system, light from optical path **102** is sent to an optical splitter **104**, filter **106**, focusing optics **108**, to the optical energy detector **110**. The optical energy detector **110** is adapted to detect light at the wavelength D2. Some of the light passes through the splitter **104**; this light goes to the second splitter **112**. Half of the light is sent to the optical energy detector **114**. The other portion of the light is sent to the optical splitter **116**. The optical splitter **116** sends half of the light to the optical energy detector **118** and half of the light to the optical mirror **120**. The mirror **120** sends the light to the optical energy detector **122**. In this example, more light is sent to the optical energy detector **110** than is sent to the other optical energy detectors **114**, **118** and **122**.

**[0004]** Figure 1B illustrates a prior art system in which light from a fiber optic cable is split. In this example, the optical fiber **128** is split into three branches that equally distribute the light to the optical energy detectors **130**, **132**, **134** and **136** after passing through filters **138**, **140**, **142** and **143**.

## SUMMARY OF THE PRESENT INVENTION

**[0005]** The present invention uses wavelength preferential optical wavelength splitters in an optical path in order to be more efficient in optical wave energy wavelength separation than conventional optical splitters.

**[0006]** One embodiment of the present invention is a multichannel wavelength measuring device including multiple optical detectors. Each detector is adapted to detect light at a different wavelength. The multichannel wavelength device also includes a sequence of optical wavelength splitters in an optical path. Each of the optical splitters is adapted to preferentially provide light to a least one of the detectors at the desired detecting wavelength of the detector.

**[0007]** One embodiment of the present invention uses optical splitters to preferentially provide light from an optical path to detectors at the desired detected wavelength of the detectors. The method also uses the detector to detect light at the desired detected wavelength.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** Figure 1A is a diagram that illustrates a prior art system using optical splitters.

**[0009]** Figure 1B is a diagram that illustrates a prior art fiber optical splitter.

**[0010]** Figure 2 is a diagram that illustrates an embodiment of the present invention using filter that preferentially provides light at certain wavelengths to optical detectors.

**[0011]** Figure 3A-3C is a diagram that illustrates an exemplanary embodiment of the optical transmission characteristics of the optical splitters of figure 2.

**[0012]** Figure 4 is a diagram that illustrates an alternate embodiment of the present invention.

## DETAILED DESCRIPTION

**[0013]** Figure 2 shows a multichannel wavelength measurement device **200**. Multiple optical detectors are provided to detect light at different wavelengths. In this example, detectors **202, 204, 206** and **208** shown. These detectors can be of conventional design used to detect light at certain wavelengths. For the purposes of this patent application, the term "light" includes both visible light and other forms of optical energy, such as infrared light. A sequence of optical splitters **208, 210** and **212** are placed in the optical path **214**. The optical splitters are adapted to preferentially provide enough light to one of the detectors at the desired detected wavelength of the detector. For example, in Figure 2, the optical splitter **208** preferentially reflects light at wavelength D1 to the optical detector. In one embodiment, the optical splitter **208** preferably transmits light at the wavelengths D2, D3 and D4 to detectors **208, 204** and **206**. Also shown in Figure 2 is an optical mirror **216**. The optics **218, 220, 222** and **224** can be used to focus the light to the detectors **202, 204, 206** and **208**. Looking again

at Figure 2, note that this embodiment does not show filters associated with the detectors **202**, **204**, **206** and **208**. However, additional optical band pass filters may be used to further filter the light energy going to the detectors.

**[0014]** The efficiency of the optical energy detected is improved over the prior art systems. By preferentially providing light using the optical splitters rather than using a traditional optical splitter, more of the optical energy at the wavelengths of interest are sent to the detectors. Preferentially providing light means reflecting or transmitting light at a desired wavelength more than at other wavelengths. Figure 2 illustrates an example where 80% of the optical energy of interest is removed from the optical path by each optical splitter. The system of the present invention can be calibrated so that it can compensate for splitter transmission variations. In one embodiment, this calibration is done by sending a test signal through the system and measuring the output from the detectors. Such a calibration is typically already required due to variations in the detector and optics alignment.

**[0015]** Figure 2 shows light of specific wavelengths being extracted from a single optical path section. The optical path can also be fanned out with both reflective and transmitted light from an optical filter **208** sent to additional optical splitters.

**[0016]** Figure 3A illustrates exemplary optical transmission characteristics of the optical filter 208 of Figure 2. Note that the energy at wavelength D1 is reflected while energy wavelengths of D2, D3 and D4 are transmitted. The advantage of optical splitter of Figure 2 is that a large percentage of the energy at D1 is transmitted to the optical detector **202** while allowing the energy of other wavelengths to be transmitted to the other detectors. Figure 3B shows an optical splitter in which a large percentage of the energy at wavelength D1 is reflected to the detector **204** while energy at wavelengths, D3 and D4 are transmitted to the other detectors. Figure 3C shows an optical splitter for which energy at wavelength D3 is sent to detector **206** while energy at wavelength D4 is transmitted to be sent to the detector **208**.

**[0017]** The selective optical splitters can be produced in a number of different fashions. For example, dialectic material can be deposited upon a glass surface to form a stack that preferentially transmit light at certain frequencies. Such optical high or low pass filters for use as splitters are commercially available. In one embodiment, the light enters the optical splitter at an angle and this can effect the transmission characteristics. In the example of Figures 3A-3C each of the optical splitters operates as a high pass filter.

**[0018]** Figure 4 shows a system **400** with an optical splitter **402** that operates as a low pass filter passing light at the wavelength D1 to the wavelength detector **404** while reflecting light at wavelengths D2, D3 and D4 to the remainder of the system.

**[0019]** Multi-wavelength optical detectors are used in the pulp and paper industry for example in moisture and coat weight sensors. A detected signal at a wavelength that indicates the presence of water can be divided by detected signal at a reference wavelength. The use of the reference wavelength removes the dependency of the system to source or path variations.

**[0020]** The foregoing description of preferred embodiments of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims and their equivalence.